Instruments for In Situ Titan Missions

Patricia M Beauchamp
Jet Propulsion Laboratory-California Institute of Technology (321-560)
Pasadena, CA 91109
818 354-0529
pbeaucha@jpl.nasa.gov

Jonathan Lunine
Dipartimento di Fisica, Università degli Studi di Roma "Tor Vergata"
Via della Ricerca Scientifica, 1
00133 Rome, Italy
Tel. +39 06 7259 4097/+39 06 4993 4362,
jlunine@roma2.infn.it

Athena Coustenis
LESIA, Observatoire de Paris-Meudon
5, place Jules Janssen
92195 Meudon Cedex
France
Tel: +331 45077720
Athena.Coustenis@obspm.fr

Peter Willis
Jet Propulsion Laboratory-California Institute of Technology
Pasadena, CA. 91109
(818) 325-9356
Peter.A.Willis@jpl.nasa.gov

George Cody
Geophysical Laboratory
Carnegie Institute,
Washington, DC
(202) 478-8980
gcody@ciw.edu

Kim R. Reh
Jet Propulsion Laboratory-California Institute of Technology
Pasadena, CA. 91109
818-354-2655
Kim.R.Reh@jpl.nasa.gov

Other than Earth, Titan is the only world in our solar system known to have standing liquids and an active “hydrologic cycle” with clouds, rains, lakes and streams. Cassini-Huygens has provided spectacular data and has provided us with a glimpse of the mysterious surface of Titan (Lebreton et al. 2009). However the mission will leave us with many questions that require future missions to answer. These include determining the composition of the surface and the geographic distribution of various organic constituents.

The dense atmosphere and hydrocarbon lakes on Titan’s surface can be explored with airborne platforms and landed probes, but the key aspect ensuring the success of future investigations is the conceptualization and design of instruments that are small enough to fit on such platforms, and yet be sophisticated enough to conduct the kinds of detailed chemical (including isotopic), physical, and structural analyses needed to understand the history and cycling of the organic materials. In addition, they must be capable of operating at cryogenic temperatures while maintaining the integrity of the sample throughout the analytic process. Illuminating accurate chemistries also requires that the instruments and tools are not simultaneously biasing the measurements due to localized temperature increases. While the requirements for these techniques are well understood, their implementation in an extremely low temperature environment with limited mass, power and volume is acutely challenging.

Over the last few years there have been a number of mission studies that involve either landing in a lake on Titan or circumnavigating Titan in a balloon (Coustenis et al. 2009; Titan Saturn System Mission Final and Joint Reports). Science teams have identified investigations on these platforms that require instruments to have high resolution and high sensitivity but be lightweight and low-power to minimize mass which can also reduce mission cost (Coustenis et al. 2011). The need for high resolution and sensitivity follows from an examination of the Cassini-Huygens data and understanding what is required to interpret the complex chemistry occurring in the atmosphere and on the surface. Novel instruments are required to determine environmental conditions at the surface, such as humidity and winds as well as probe the physical properties of the lakes. Advances in the technologies required for sampling the high latitude lakes - cryogenic sample acquisition and sample handling - are also essential, as are techniques for sampling cryogenic aerosols and dune materials.

Because of the plentiful supply of organic material and the environmental differences, in situ instruments developed for Mars are not suitable for Titan in situ missions. New instrument paradigms must be adopted for long term operation at 94K. Developing components operable in the extreme conditions found on Titan’s surface can simplify the design of the landed element or balloon platforms and reduce operational complexities. This presentation will discuss some of the instrument and sampling systems needed for these scientifically challenging investigations and point out some of the technologies which can enable new concepts for flight instruments to study the physical properties and surface chemistry of Titan.

Reference:

1. Lebreton, J-P., Coustenis, A., Lunine, J., Raulin, F., Owen, T., Strobel, D., 2009. Results from the Huygens probe on Titan. Astron. & Astrophys. Rev. 17, 149-179.
2. Coustenis, A., and 157 co-authors, 2009. TandEM: Titan and Enceladus mission. *Experimental Astronomy* **23**, 893-946.
3. TSSM Final Report, 3 November 2008, NASA Task Order NMO710851
4. TSSM NASA/ESA Joint Summary Report, 15 November 2008, NASA Task Order NMO710851
5. Coustenis, A., Atkinson, D., Balint, T., Beauchamp, P., Atreya, S., Lebreton, J-P., Lunine, J., Matson, D., Erd, Ch., Reh, K., Spilker, T., Elliott, J., Hall, J., Strange, N., 2011. Atmospheric planetary probes and balloons in the solar system. *J. Aerospace Engineering* **225**, 154-180.